DESCRIPTION OF MAP UNITS

PLAINS MATERIALS

pvs VERY SMOOTH PLAINS MATERIAL—Occurs only on floors of c_5 craters (FDS 27382). Moderate to low (0.13–0.16) uniform albedo; surface smooth at all resolutions; very low density of small superposed craters. Sharp contacts with central peaks and walls of craters. *Interpretation:* Mostly impact melt pooled by fallback in crater floors; in large craters, such as Equiano (lat 39° S., long 31° W.), may be volcanic, induced by impact

ps SMOOTH PLAINS MATERIAL—Occurs throughout quadrangle in relatively small patches within and between craters (FDS 166668). Crater density 1.3×10^2 (>10 km)/10^6 km^2; moderate albedo, but includes circular patches and irregular blotches of brighter material; small tracts and tracts near terminator do not show mottling (FDS 166619). Very gentle rolling relief interrupted by rare scarps 100 to 600 m high (FDS 27424). Sharp contacts with adjoining high ground. *Interpretation:* Mostly volcanic; unequivocal volcanic vents and lava flow fronts not observed; smaller patches (<50 km) may be melted fallback or accumulations of loose debris pooled in lows by secondary-impact events

psi INTERMEDIATE PLAINS MATERIAL—Occurs within c_1 to c_3 craters and basins (FDS 166675) where its crater density is higher than that of nearby smooth plains unit and lower than that of nearby intercrater plains unit (FDS 27428); also mapped as patches within intercrater plains unit on basis of crater density; moderate albedo and some patches of low albedo. Small pits and hills rare to common. Gradational contacts with units of adjoining high ground. Mapped as cratered plains material in Kuiper quadrangle (De Hon and others, 1981). *Interpretation:* Mostly volcanic; smaller patches (<50 km) may be melted fallback or accumulations of loose debris pooled in lows by secondary-impact events. Most occurrences within craters are clearly younger than intercrater plains unit; tracts shown enclosed by intercrater unit may be contemporaneous with it

pi INTERCRATER PLAINS MATERIAL—Forms widespread, gently rolling ground between large craters and basins; especially extensive in northwestern part of quadrangle where large c_1 and c_2 craters are rare (FDS 166653). Albedo medium to low (0.13–0.17); crater density 3.0 to 6.0×10^2 (>10 km)/10^6 km^2. Overlapped by c_3 craters and basins. Rare subsequent scarps and ridges. Most superposed craters less than 10 km in diameter are shallow and irregular in shape, and many occur in strings and clusters, suggesting secondary-crater morphology (FDS 27420). Mapped in part as rough terra material in Kuiper quadrangle (De Hon and others, 1981) in area of overlap of northern part of Discovery quadrangle. *Interpretation:* Volcanic materials of regional extent; probably includes unmapped tracts of intermediate plains material that may be younger than c_1 and c_2 craters

RELIEF-FORMING MATERIALS

hl HILLY AND LINEATED MATERIAL—Limited to area near northeast corner of quadrangle. Forms hills and intervening hollows 5 to 10 km wide; hills are 0.1 to 1.8 km high (FDS 27422: 27463). Area cut by numerous lineaments trending generally N. 50°–60° W., some lineaments consist of open-ended, coalescing scalloped depressions. Preexisting crater rims broken into hills and depressions like those on adjacent ground; no undeformed c_3 or older craters. *Interpretation:* Material subjected to intense deformation and erosion, perhaps by focusing of seismic energy at the antipode to the Caloris Basin

ph HUMMOCKY PLAINS MATERIAL—Occurs only as patches within modified craters on or near hilly and lineated material (FDS 27423). Forms level areas studded with hummocks averaging 2 km in width; hummocks smaller and farther apart than those of adjacent hilly and lineated unit. *Interpretation:* Formed by same processes that formed hilly and lineated unit but initial material different, resulting in smaller and sparser hummocks; initial material may have been intermediate plains unit

CRATER AND BASIN MATERIALS.

The morphology of virtually all mercurian craters and basins is comparable to that of lunar craters and basins, when allowance is made for differences in gravity on the two bodies, indicating that mercurian craters and basins almost certainly formed by impact. Crater and basin materials are mapped according to their relative ages as determined by apparent degree of degradation and local overlap relation. The age classification is that of N. J. Trask in McCauley and others (1981). Craters smaller than 30 km in diameter are not mapped

c_5 Material of rims, walls, and floors of very sharp rimmed craters (FDS 27382)—Flat floors, well-defined wall terraces, sharp break between wall and floor. Larger craters surrounded by well-defined continuous field of relatively crisp satellitic craters. Some c_5 craters can be seen under high solar-illumination angles to have bright halos (albedo 0.20–0.27), rays, and areas of anomalously low albedo (FDS 166653)

cp_5 Material of single or multiple rugged peaks near center of c_5 crater

cr_5 Material of radial-rim facies of very sharp rimmed craters—Anastomosing radial ridges grade outward to irregular hills and valleys that grade to individual satellitic craters (FDS 27382). Around craters <70 km in diameter, individual ridges and valleys cannot be discerned, but unit appears to mantle surrounding topography

cs_5 Material of small, crisp, elongate, and coalescing craters clustered around or radial to large c_5 craters

c_4 Material of rims, walls, and floors of slightly subdued craters and basins (FDS 166669)—Terraces and wall structure present; sharp break at base of wall; more superposed craters than c_5 class. Larger craters and basins have flat floors, prominent, continuous rims, slightly modified terraces or other wall features, and well-preserved, extensive satellitic crater fields; many filled with plains, so central peaks and inner rings, if present, are not evident

cp_4 Material of single or multiple rugged peaks near center of c_4 crater

cr_4 Material of radial-rim facies of slightly subdued craters and basins—Irregular ridges and valleys as much as 5 km across that are roughly radial to c_4 craters and grade outward to irregular, elongate, subdued satellitic craters (FDS 27416)

cs_4 Material of small, subdued, elongate, and coalescing craters roughly radial to large c_4 craters and basins

c_3 Material of rims, walls, and floors of subdued craters and basins (FDS 166650)—Low, rounded rims and some remnants of wall structures; flat floors, many filled with plains materials; floor-wall boundary indistinct in many craters. Larger craters and basins have modified but intact rims, walls with discontinuous terraces, and discontinuous fields of satellitic craters (FDS 166671)

cp_3 Material of single or multiple subdued peaks near center of c_3 crater

cr_3 Material of radial-rim facies of subdued basins (FDS 27415)—Irregular hummocks and depressions with vague radial texture

cs_3 Material of small, highly subdued, elongate, and coalescing— craters roughly radial to large c_3 craters and basins (FDS 166646)

c_2 Material of highly degraded craters and basins (FDS 27418)— Shallow, pan-shaped; no wall structure. Larger craters and basins have flat floors and low but continuous rims bearing many smaller superposed primary and satellitic craters; a few have low central peaks; one has inner concentric ring; all flooded by plains materials

cp_2 Material of isolated low peak near center of c_2 craters and basins and material of peak ring in crater Chekhov (lat 36° S., long 62° W.)

rrl Material of Raphael Basin—Lineated terrain with strings of coalescing craters and a few elongate hummocks, radial to Raphael Basin, which is located to north in Beethoven quadrangle (FDS 166640). Unit poorly defined because of high sun angle

cs_2 Material of small, highly subdued, elongate, and coalescing craters roughly radial to large c_2 basin (FDS 166685)

c_1 Material of nearly destroyed craters and basins (FDS 274l9)—Relatively large, flat-floored; extremely low or discontinuous rims rising only slightly above surrounding plains; all flooded by plains units

CONTACT

FAULT—Bar and ball on downthrown side

RIDGE—Barbs point downslope

SCARP—Line at base of slope; barb points downslope

FISSURE OR DEPRESSION OF STRUCTURAL ORIGIN—Found only in hilly and lineated material (unit hl)

LINEAMENT—Trough, ridge, or scarp with low relative relief

CRATER RIM CREST

CRATER RIM CREST, GREATLY SUBDUED OR BURIED

AREA OF BRIGHT CRATER-RAY MATERIAL—Shown around some craters too small to map; shown primarily in northwest quarter of map where illumination angle allows discrimination

AREA OF ANOMALOUSLY LOW ALBEDO—Shown only in northwest quarter of map where illumination angle allows discrimination

INTRODUCTION

The Discovery quadrangle lies within the heavily cratered part of Mercury in a region roughly antipodal to the 1300-km-wide Caloris Basin. Like the rest of the heavily cratered part of the planet, the quadrangle contains a spectrum of craters and basins ranging in size from those at the limit of resolution of the best photographs (200 m) to those as much as 350 km across, and ranging in degree of freshness from pristine to severely degraded. Interspersed with the craters and basins both in space and time are plains deposits that are probably of several different origins. Because of its small size and very early segregation into core and crust, Mercury seemingly has been a dead planet for a long time—possibly longer than the Moon (Murray and others, 1975; Trask and Guest, 1975). Its geologic history, therefore, records with considerable clarity some of the earliest and most violent events that took place in the inner Solar System.

STRATIGRAPHY

CRATER AND BASIN MATERIALS

As on the Moon and Mars, sequences of craters and basins of differing relative ages provide the best means of establishing stratigraphic order on Mercury (Pohn and Offield, 1970; Stuart- Alexander and Wilhelms, 1975). Overlap relations among many large mercurian craters and basins are clearer than those on the Moon. Therefore, as this map shows, we can build up many local stratigraphic columns involving both crater or basin materials and nearby plains materials.

Over all of Mercury, the crispness of crater rims and the morphology of their walls, central peaks, ejecta deposits, and secondary-crater fields have undergone systematic changes with time. The youngest craters or basins in a local stratigraphic sequence have the sharpest, crispest appearance. The oldest craters consist only of shallow depressions with slightly raised, rounded rims, some incomplete. On this basis, five age categories of craters and basins have been mapped; the characteristics of each are listed in the explanation. In addition, secondary crater fields are preserved around proportionally far more craters and basins on Mercury than on the Moon or Mars, and are particularly useful in determining overlap relations and degree of modification.

PLAINS MATERIALS

All low-lying areas and the areas between craters and basins in the Discovery quadrangle are covered by broadly level, plains-forming material, except for small areas covered by the hilly and lineated material and hummocky plains material described below. Tracts of plains materials range in size from a few kilometers across to intercrater areas several hundred kilometers in width. This material is probably not all of the same origin. Strom and others (1975) and Trask and Strom (1976) cited evidence that many large areas of plains are of volcanic origin. Smaller tracts are more apt to be impact melt, loose debris pooled in low spots by seismic shaking (Schultz and Gault, 1975), or ejecta from secondary impacts (Oberbeck and others, 1977). The origin of many individual tracts must necessarily remain uncertain without additional information.

Plains materials have been grouped into four units on the basis of both the density of super- posed craters and the relation of each unit to adjacent crater and basin materials. These units are listed as follows from oldest to youngest. (1) Intercrater plains material (unit pi) is widespread, has a high density of small craters (5 to 15 km in diameter), and appears to predate most of the relatively old and degraded craters and basins, although some tracts of intercrater plains material may be younger than some old craters. (2) Intermediate plains material (unit psi) is less abundant than the intercrater plains unit and has a density of superposed small craters that is intermediate between those of the intercrater plains and smooth plains units. The intermediate plains material is most readily mapped on the floors of those c_1, c_2, and c_3 craters and basins that are surrounded by intercrater plains material with a distinctly higher crater density (FDS 27428). Contacts between intercrater plains and intermediate plains units that occur outside mapped craters and basins are gradational and uncertain. In parts of the quadrangle, photographic resolution and lighting do not permit the intermediate plains unit to be separated from the intercrater plains or smooth plains units with a high level of confidence. (3) Smooth plains material (unit ps) occurs in relatively small patches throughout the quadrangle on the floors of c_4 and older craters and basins and in tracts between craters. More bright-halo craters occur on this unit than on either the inter- crater plains or intermediate plains units. (4) Very smooth plains material (unit pvs) occurs on the floors of some of the youngest craters. In summary, a complex history of contemporaneous formation of craters, basins, and plains is thus indicated by the mapping.

RELIEF-FORMING MATERIALS

The Discovery quadrangle includes some of the most distinctive relief-forming material on the planet, the hilly and lineated terrain unit mapped by Trask and Guest (1975). The unit consists of a jumble of evenly spaced hills and valleys about equal in size. Most craters within this material appear to predate its formation, and their ages cannot be estimated: their rims have been disrupted into hills and valleys identical to those of the hilly and lineated unit; the floors of some of these degraded craters contain hummocky plains material (unit ph) that resembles the hilly and lineated unit, except that the hills are fewer and lower.

The hilly and lineated unit and the enclosed hummocky plains unit appear to be relatively young; they may be the same age as the Caloris Basin. In addition, they lie almost directly opposite that basin on the planet. Both observations strengthen the suggestion that the hilly and lineated unit and the hummocky plains unit are directly related to the formation of Caloris (Schultz and Gault, 1975), possibly through the focusing of seismic waves at the antipodal point.

STRUCTURE

Morphologically diverse scarps, ridges, troughs, and other structural lineaments are relatively common in the Discovery quadrangle. Dzurisin (1978) documented a well-developed pattern of linear lithospheric fractures in the quadrangle that predate the period of heavy bombardment. A dominant structural trend is recognized at N. 50°–45° W., and subsidiary trends occur at N. 50°–70° E. and roughly due north. Joint-controlled mass movements were most likely responsible for the fact that many craters of all ages have polygonal outlines, and some linear joints may have provided surface access for lavas that formed the intercrater plains. Evidence of the latter may be recorded by several linear ridges that may have been formed by lava accretion along linear volcanic vents (for example, Mirni Rupes at lat 37° S., long 40° W., FDS 27420).

Planimetrically arcuate escarpments in the Discovery quadrangle cut intercrater plains and crater materials as young as c_4. These scarps are typically 100 to 400 km long and 0.5 to 1.0 km high, and they have convex-upward slopes in cross section that steepen from brink to base. More trend closer to north-south than to east-west. Discovery (lat 55° S., long 38° W.), Vostok (lat 38° S., long 20° W.), Adventure (lat 64° S., long 63° W.), and Resolution (lat 63° S., long 52° W.) Rupes are the most prominent examples in the quadrangle. Vostok transects and foreshortens the crater Guido d'Arezzo, which suggests that arcuate scarps are compressional tectonic features (thrust or high-angle reverse faults). Melosh and Dzurisin (1978) have speculated that both arcuate scarps and the global mercurian lineament pattern may have formed as a result of simultaneous despinning and thermal contraction of Mercury.

Planimetrically irregular scarps on the floors of many plains-filled craters and basins are the youngest recognized structural features in the quadrangle, as they cut both the smooth plains and intermediate plains materials. Their occurrence inside only smooth-floored craters and basins suggests that the stresses responsible for their formation were local in extent, perhaps induced by magma intrusion or withdrawal beneath volcanically flooded craters.

GEOLOGIC HISTORY

Any reconstruction of mercurian geologic history must include the inference that at an early time the planet was differentiated into a core and crust. Mercury has a weak magnetic field (Ness and others, 1976) coupled with high density. Both facts can most easily be accounted for by the presence of an iron core, possibly liquid, roughly 4,200 km in diameter, overlain by a silicate crust a few hundred kilometers thick. The postulated volcanic origin of a substantial fraction of the Mercurian plains also implies a thick silicate crust, and thereby supports the existence of a large iron core (Murray and others, 1975).

Early, rather than late, differentiation of Mercury is attested to by the compressional scarps that are so clearly seen in the Discovery quadrangle. Segregation of the core must have released large amounts of heat, which would have resulted in significant expansion of the crust (Solomon, 1976; Solomon and Chaiken, 1976). However, unambiguous extensional features (very rare on the planet as a whole) are not seen in the Discovery quadrangle; only compressional scarps occur. Thus, core segregation occurred relatively early (before formation of a solid lithosphere) and was followed by cooling and contraction, the last phases of which probably contributed to the formation of arcuate scarps that predated the end of heavy bombardment (Dzurisin, 1978).

Rotational breaking by solar torques is another process likely to have occurred early in Mercurian history (Goldreich and Soter, 1966). With the formation of a solid lithosphere, stresses induced by tidal despinning most likely were sufficient to cause widespread fracturing. Melosh (1977) has shown analytically that the expected pattern of fracturing includes linear strike-slip faults oriented roughly N. 60° W. and N. 60° E., and a younger set of thrust faults with east-west throw and rough north-south trends. Melosh and Dzurisin (1978) have pointed out the similarity between this predicted tectonic pattern and that observed on Mercury, and they have proposed that the global system of lineaments and arcuate scarps, which is well developed in the Discovery quadrangle, formed in response to early, simultaneous planetary contraction and tidal despinning.

The observable stratigraphic record in the Discovery quadrangle starts with formation of the intercrater plains, parts of which may have been coeval with the oldest observable craters. During this period, rates of volcanism were probably high as heat from core formation was being dissipated. If the crust was in a state of extension, there would have been easy pathways for large volumes of magma to reach the surface. The resulting plasticity of the crust probably caused large numbers of c_1 and c_2 craters to be destroyed by isostatic adjustment (Malin and Dzurisin, 1977; Schaber and others, 1977), so the present inventory of c_1 and c_2 craters may not be complete.

By c_3 time, the rate of volcanism had declined although the impact rate was still high. The preservation of many secondaries 1 to 5 km across around c_3 basins indicates that surface flows that would have obliterated them were highly restricted. However, some degradation of c_3 basins occurred by isostatic adjustment. Most of the intermediate plains material formed at this time. Smooth plains material appears to be largely coeval with c_4 craters and basins. The crust was under compression during c_3 and c_4 time, inasmuch as the compressional scarps and ridges post- date some c_3 and c_4 craters, and are cut by some c_4 craters and by c_5 craters. Formation of intermediate and smooth plains materials may have been abetted by the c_3 and c_4 crater- and basin-forming events that opened up temporary magma conduits. One of the latest large impacts was the Caloris event, which occurred on the other side of the planet from the Discovery quadrangle and which may have initiated formation of the hilly and lineated material within it.

Subsequent to formation of the smooth plains material, the Discovery quadrangle underwent minor tectonic adjustments that formed scarps on plains within craters. The very smooth plains unit was formed in some young craters. The only other activity was a steady rain of relatively small impacts, apparently at about the same rate as on the Moon.

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NOTES ON BASE

This map sheet is one of a series covering that part of the surface of Mercury that was illuminated during the Mariner 10 encounters (Davies and Batson, 1975). The source of map data was the Mariner 10 television experiment (Murray, 1975).

ADOPTED FIGURE

The map projections are based on a sphere with a radius of 2439 km.

PROJECTION

The Lambert conformal conic projection is used for this sheet, with a scale of 1:4,623,000 at lat 22.5° S. Latitudes are based on the assumption that the spin axis of Mercury is perpendicular to the plane of the orbit. Longitudes are positive westward in accordance with the usage of the International Astronomical Union (IAU, 1971). Meridians are numbered so that a reference crater named Hun Kal (lat 0.6° S) is centered on long 20° (Murray and others, 1974; Davies and Batson, 1975).

CONTROL

Planimetric control is provided by photogrammetric triangulation using Mariner 10 pictures (Davies and Batson, 1975). Discrepancies between images in the base mosaic and computed control—point positions appear to be less than 5 km. No attempt was made to resolve discrepancies in feature positions on this sheet and those on the Kuiper (H-6) quadrangle to the north and the Bach (H-l 5) quadrangle to the south. The latter sheets were controlled by an earlier, more preliminary net.

MAPPING TECHNIQUES

Mapping techniques are similar to those described by Batson (1973a, 1973b). A mosaic was made with pictures that had been digitally transformed to the Lambert conformal conic projection. Shaded relief was copied from the mosaics and portrayed with uniform illumination with the Sun to the west. Many Mariner 10 pictures besides those in the base mosaic were examined to improve the portrayal. The shading is not generalized and may be interpreted with nearly photographic reliability (Inge, 1972; Inge and Bridges, 1976).

Shaded relief analysis and representation were made by Susan L. Davis.

NOMENCLATURE

All names on this sheet are approved by the International Astronomical Union (IAU, 1977).

H-11	Abbreviation for Mercury (Hermes) sheet number 11.
H 5M –45/45 G:	Abbreviation for Mercury (Hermes) 1:5,000,000 series; center of sheet, lat –45°; long 45°; geologic map, G.

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